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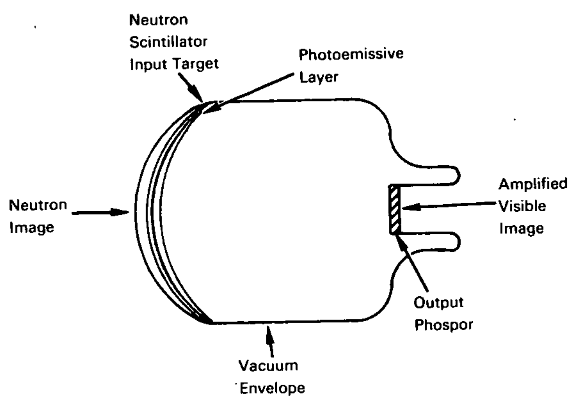
AEC-NASA TECH BRIEF

Thermal Neutron Image Intensifier Tube Provides Brightly Visible Radiographic Pattern



The problem:

To improve current methods of image detection in thermal neutron radiographic inspection. Neutron radiography provides meaningful images of material combinations, which are not easily radiographed by conventional techniques; it provides another method for nondestructive testing. Sufficient image intensification must be obtained so that it is feasible to use commercially available nonreactor neutron sources. Brightness must also be of sufficient intensity to enable fluoroscopic viewing of image without dark adaptation. A system for observing motion in the neutron radiographic image area is also needed.

The solution:

A vacuum-type neutron image intensifier tube consists of an input target (a combination of a neutron scintillator and photoemissive layer) and an output phosphor screen. The incoming image is converted to an electron image. A high voltage acceleration of the imaging electrons, together with demagnification between the input target and the output screen, contributes to the production of an intensified bright visible image.

How it's done:

An evacuated glass envelope was constructed with an input phosphor screen, 22 cm in diameter. The input target (approximately 0.4 mm thick) consists of a neutron scintillator and a photoemissive layer. This scintillator is a powder mixture of lithium fluoride and ZnS (Ag) in a weight ratio of 1:4. To provide this powder mixture with a high neutron cross-section for a prompt neutron-alpha reaction, LiF is 95.72% enriched with Li-6. Absorption of a neutron by the scintillator results in the emission of an alpha particle. As a result, the ZnS (Ag) phosphor is stimulated to emit light. The light causes the emission of electrons from the adjacent photoemissive layer. The electrons emitted from the photoemissive layer are maintained in an image sense and accelerated toward the phosphor output screen by a voltage of about 30 kv. This

(continued overleaf)

produces a bright visible image of the incident neutron pattern.

The neutron image obtained at the intensifier tube output is observed by means of a 525-line, 30-frame/sec, interlaced, closed circuit television system. A vidicon system can be used for neutron intensities as low as 2×10^4 n/cm^2 sec.

Notes:

1. Initial experimentation was conducted at Argonne's Juggernaut reactor facility and involved the use of a vidicon closed circuit television system. Object spacing resolution was observed to be approximately 0.5 mm. Movements as fast as 5m/min could be followed without blur. Imaging thickness changes as small as 4% could also be observed in materials such as steel and uranium. In addition, it was found that radiographic inspection of radioactive material was practically unaffected by gamma radiation levels of 4000 R/hr with the available neutron intensity (2×10^7 n/cm^2 sec).
2. The above television system makes it possible to conduct motion investigations using thermal neutrons. For example, the thermal expansion of nuclear reactor fuel and the flow of water in metal pipes are now being studied. Casting of high density materials has been suggested as a future application.
3. Three tubes have been made and tested. The best tube provides a light yield of about 50 ft -lamberts at 10^7 n/cm^2 sec, a high contrast resolution of 0.35 mm, and improved neutron–gamma response (about a factor of two better than shown in Note 1). Further improvements in this latter factor and in resolution capability are now being sought in tubes under development.
4. Additional details are contained in *IEEE Transactions on Nuclear Science,* April 1966, p. 79–83.
5. Inquiries concerning this innovation may be directed to:

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   9700 South Cass Avenue
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   Reference: B67-10296

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Patent status:

Inquiries about obtaining rights for commercial use of this innovation may be made to:

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